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# **PROPULSION DIRECTORATE**

## **Monthly Accomplishment Report December 2002**

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**BETTER MATERIALS FOR SPACE APPLICATIONS:** Over the past few years, the Propulsion Directorate's Polymer Working Group has been synthesizing and testing POSS (polyhedral oligomeric silsesquioxanes)-polymers for increased space-survivability. This work, funded by the Air Force Office of Scientific Research (AFOSR) and PR, is an offshoot of solid rocket motor POSS-insulation development efforts. In the Low Earth Orbit environment, atomic oxygen makes up 90% of the atmosphere and causes rapid degradation of typical polymer systems. The POSS-insulation research showed that in a severe oxidizing environment, the organic polymer and organic groups around the POSS cage burn off, and the silicon and oxygen of the POSS framework oxidize to form  $\text{SiO}_2$ . The Polymer Working Group has since conclusively demonstrated that, when exposed to atomic oxygen, POSS-polymers form a passivating ceramic layer that protects the virgin polymer underneath. This results in extended lifetime for the POSS-polymer in Low Earth Orbit. Because POSS is dispersed throughout the polymer (unlike protective coatings), it can self-heal in damaged areas. Furthermore, in many cases the incorporation of POSS enhances the physical and mechanical properties of the polymer. This multifunctional capability is unmatched in any known polymer system for space. The value added to man-made orbiting bodies is estimated to be a factor of 2-3 increase in lifetime when material survivability is the key factor. For their achievements, the Space-Survivable POSS-Polymer Team was honored as the 4<sup>th</sup> Quarter FY02 Propulsion Directorate In-House Project of the Quarter. This team is made up of Capt Rene I. Gonzalez (AFRL/PRSM), Dr. Sandra Tomczak (ERC), Prof. Tim Minton (Montana State University), and Prof. Gar Hoflund (Florida State University). In addition, the success of this program has resulted in the funding of a multiyear DARPA R&D program which will be carried out by the aforementioned awardees and their business collaborators, Hybrid Plastics and Triton. (S. Phillips, AFRL/PRSM, (661) 275-6270)



Capt Rene I. Gonzalez and Dr. Sandra Tomczak



Prof. Tim Minton



Prof. Gar Hoflund

**CHRISTE WINS PRESTIGIOUS CHEMISTRY AWARD:** Dr. Karl O. Christe, a researcher with the Propulsion Directorate's Propellants Branch (AFRL/PRSP) at Edwards AFB, has been named the recipient of the 2003 American Chemical Society (ACS) Inorganic Chemistry Award for his lifetime achievements. Dr. Christe, whose efforts are primarily funded by the Defense Advanced Research Projects Agency (DARPA) with additional support from the Air Force Office of Scientific Research (AFOSR), has been on the cutting edge of efforts to develop High Energy Density Matter (HEDM) chemistry. Dr. Christe and his coworkers are best known for their discovery of the  $N_5$  cation in 1999. It was the first demonstration of a stable and energetic nitrogen species since the discovery of the  $N_3$  anion 110 years prior. The use of theoretical chemistry, high-speed computer systems, and the experimental skills of Dr. Christe's coworkers supported the successful demonstration of the  $N_5$  cation. Dr. Christe created worldwide headlines in 1986 for developing a process for the preparation of elemental fluorine by chemical means, which was thought to be impossible at the time. This chemical process had been attempted



Dr. Karl O. Christe is the recipient of the 2003 ACS Inorganic Chemistry Award

unsuccessfully by researchers ever since Moissan discovered the element fluorine 160 years ago. Dr. Christe recently won the 2000 Prix Moissan, the highest international prize in fluorine chemistry, and he also won the 1986 ACS Award for Creative Work in Fluorine Chemistry. He is also active as a research professor at the Loker Hydrocarbon Research Institute of the University of Southern California. He has published more than 300 peer-reviewed papers and holds more than 60 patents. Considered a trailblazer,

Dr. Christe is frequently cited in inorganic chemistry textbooks. His efforts continue to advance the world of chemistry, and the understanding and application of those advances will provide rocket propulsion and energetic materials for the future. The ACS Inorganic Chemistry Award has been sponsored by the Aldrich Chemical Company Inc since 1998. Dr. Christe will be presented the award in a ceremony at the 225<sup>th</sup> ACS National Meeting in New Orleans on 25 March 2003. (R. Channell, AFRL/PRSP, (661) 275-5762)

Want more information?

- ❖ The American Chemical Society's webpage on the Inorganic Chemistry Award is available by clicking [here](#).

**EMISSIONS TESTS WITH JP-8+100 CONDUCTED:** From 14-22 November 2002, a team of scientists from the Propulsion Directorate's Fuels Branch (AFRL/PRTG), Boeing, and the University of Missouri-Rolla (UMR) conducted engine emissions tests on two T-43 aircraft at Randolph AFB, Texas. The purpose of this testing was to evaluate the impacts of the +100 fuel

thermal stability additive on engine particulate and gaseous emissions. The engine emissions tests were conducted “on-wing” on the T-43s, each equipped with two P&W JT8D-9A engines. The T-43 aircraft is the Air Force equivalent to the commercial Boeing 737 and is used for pilot and navigator training. The aircraft are currently fueled with baseline JP-8 fuel. The tests consisted of measuring the engine’s particulate and gaseous emissions with the aircraft operating on JP-8 and then on JP-8+100. After the initial tests with JP-8, both aircraft were fueled with JP-8+100 for the remainder of the study. Both engines of each aircraft were tested daily for three consecutive days after completion of a 4-hour training mission. Three particulate and three gaseous emissions probes were used in this evaluation, which allowed for the simultaneous measurement of particulate size and number, and gaseous emissions at three radial locations to assess uniformity of the emissions in the engine exhaust. The particulate measurements were conducted by UMR, and the instrumentation included condensation nuclei counters for particulate number (number of particles per cubic centimeter) measurements and a differential

mobility analyzer for determining particle size distribution. Fuel samples for each of the tests were collected to conduct chemical analysis and assess the differences between day-to-day fuel batches. In addition, the combustion characteristics (particulate loading) of the fuels will be studied in a T63 engine. Data reduction and analysis are underway and upon completion will be published and presented in a national technical conference. This effort was funded by the Environmental Security Technology Certification Program (ESTCP). (E. Corporan, (937) 255-2008 and 2Lt O. Monroig, AFRL/PRTG, (937) 255-5393)



Particulate and gaseous sampling in T-43 aircraft was recently conducted to evaluate the benefits of the +100 fuel additive on emissions

**PR MAKES SIGNIFICANT CONTRIBUTION TO MAJOR AIAA MEETING:** Propulsion Directorate personnel played a significant role in the recent 41<sup>st</sup> American Institute of Aeronautics and Astronautics (AIAA) Aerospace Sciences Meeting and Exhibit. This meeting, which was held from 6-9 January 2003 in Reno, Nevada, is the largest of the AIAA technical conferences and one of the preeminent technical gatherings for aerospace professionals. The multidisciplinary nature of this meeting provides an ideal environment for scientists and engineers from government, industry, and academia to disseminate scientific knowledge and research results. PR Government and on-site contractor personnel co-authored more than 35 of

the papers presented at the conference and also co-chaired five of the technical sessions held. Sessions co-chaired by PR personnel covered a wide range of topics including Hypersonic Air-Breathing Propulsion, Micro-fluidics Experiments & Theory, Plumes and Radiation, Plasma Assisted Combustion, and Pulse Detonation Engines. The meeting also featured the 5<sup>th</sup> Weakly Ionized Gases Workshop, chaired by PR alumnus Dr. W. Lee Bain III, and the workshop summary session included PR's Chief Scientist, Dr. Alan Garscadden, as an invited speaker. (J. Pearce, AFRL/PRO (UTC), (937) 255-5015)

Want more information?

❖ The AIAA website for the 41<sup>st</sup> Aerospace Sciences Meeting can be accessed by clicking [here](#).

HELPING HANDS DELIVERS CHRISTMAS CHEER: An article in the 20 December 2002 edition of the Wright-Patterson AFB *Skywrighter* called attention to the charitable work being done by Propulsion Directorate employees under the auspices of Project Helping Hands. Helping Hands is a charitable, non-profit organization made up of 17 PR employees with the stated goal of helping individuals and families in need in the local community. For several years, the Helping Hands team has brightened Christmas for some local families, and this year was no exception. Six local families were given presents and enough fixings to provide a complete holiday meal. In addition, the team provided these families with toiletry items, laundry detergent, paper towels, canned goods, flour, sugar, coffee, and hot chocolate. (J. Pearce, AFRL/PRO (UTC), (937) 255-5015)



Capt Michelle Rauch wraps presents in support of Helping Hands

Want more information?

❖ The *Skywrighter* article titled "Directorate Full of 'Helping Hands'" is available by clicking [here](#).